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FACSIMILE (703) 684-1157
E-Mail: fsb@alex.dgsys.com

THOMAS E. BEALL, JR.
JOHN R. MATTINGLY*
DAVID J. STANGER
SHRINATH MALUR*

GENE W. STOCKMAN
(Of Counsel)

JEFFREY M. KETCHUM
SCOTT W. BRICKNER
Registered Patent Agents

* Bar Membership Other Than Virginia

Date: February 25, 1900

Attorney Docket No. NIT-185

To: Assistant Commissioner for Patents
Washington, D.C. 20231

Sir: Transmitted herewith for filing is the patent application of:

Inventor: SEE ATTACHED LIST (K. TATSUNO et al)

For:
OPTICAL HEAD AND FABRICATION METHOD

Enclosed are:

☒ 8 Sheets of Drawings

This application is being filed without an executed Declaration.

Priority is claimed from Japanese Application No. 11-232136
filed August 19, 1999. ☐ A certified copy is attached herewith.

Copies of the disclosure documents listed on the attached PTO 1449 form and
☐ discussed in the specification or ☐ attached Information Disclosure Statement.

A verified statement to establish small entity status under 37 CFR 1.9 and 1.27.

Specification: Abstract ☒ Description 18 pages; and 27 claim(s).

Preliminary Amendment.

☒ Executed Declaration.

The filing fee is calculated as shown below:

For:	No. Filed	No. Extra
Basic Fee		
Total Claims	27 - 20 = *	7
Indep Claims	22 - 3 = +	19
<input type="checkbox"/> Multiple Dependent Claim (s)		

* If difference is less than zero
then enter '0' in second column

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Rate	Fee
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	\$ 690
x 18	\$ 126
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A check in the amount of \$ 2,298.00 is enclosed for the filing fee.

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The Commissioner is hereby authorized to charge any additional fees that may be required to
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Respectfully Submitted,

By

Thomas E. Beall, Jr.

Registration No. 22,470

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1. TITLE OF THE INVENTION

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The present invention relates to a laser module or an optical head. For example, the invention relates to a laser module or an optical head in which a semiconductor laser beam modulated by an electric signal is applied to an optical information recording medium such as an optical disc to record information on the medium or reproduce a recorded information from the medium. In particular, the invention is concerned with a laser module or an optical head each using a plurality of light sources.

In an optical head mounted on an optical disc recording and read-out apparatus, light sources and photodetectors are separated from each other. Consequently, it is impossible to attain a high fabrication integration density of light sources and photodetectors and hence it has so far impossible to attain the reduction in size and thickness of the entire optical disc apparatus. In an effort to solve this problem, a hybrid integration of photodetectors and semiconductor lasers in a reproducing head of an optical disc has been tried heretofore as is

disclosed in Japanese Patent Laid-open No. Hei 1-150244.

3. SUMMARY OF THE INVENTION

Recently there has been developed an optical disc
5 apparatus capable of playing various optical discs of CD,
CD-ROM, CD-R, and CD-Rewritable specifications having a
wavelength of 780 nm and DVD, DVD-ROM, and DVD-RAM
specifications having a wavelength of 650 nm, in which,
however, light sources and photodetectors are separated for
10 semiconductor lasers of different wavelengths. Further,
lasers of blue or purple color or even shorter wavelengths,
which are more improved in recording density, are going to
be used in future. Thus, an increase in the number of
components in the optical head will be unavoidable. Under
15 the circumstances, a further reduction in size and
thickness of the entire apparatus such as an optical disc
recording and read-out apparatus is desired.

It is an object of the present invention to improve
the above-mentioned problems. More particularly, it is an
20 object of the invention to provide a breakthrough for
reducing the size and thickness of the whole of a driver
capable of recording and reproducing information for
various optical discs.

25 According to the first means adopted in the present

invention, various semiconductor lasers of different wavelengths generated and photodetectors corresponding to those different wavelengths are subjected to alignment with a masking accuracy and then the plural semiconductor lasers are integrated as hybrid integration to reduce the number of components to a level equal to that of a monolithic configuration. According to the first means, moreover, although a plurality of optical paths have been used in the conventional optical head, a single optical path corresponds thereto.

According to the second means adopted in the present invention, index marks for alignment are affixed onto both a silicon substrate with photodetectors formed thereon and semiconductor lasers, their images are formed on a photoelectric conversion surface such as CCD and are inputted into a computer, followed by calculation of centroids of the marks and alignment. The centroid calculation permits ensuring a submicron order of alignment accuracy.

According to the third means adopted in the present invention, a reflecting mirror is formed on a silicon substrate with photodetectors formed thereon. More specifically, an off-axis substrate of 9.7 degrees or so is provided, then a reflecting mirror of 45 degrees or so is formed thereon by an anisotropic etching of silicon, and a

beam emitted from a semiconductor laser is reflected by the mirror and is bent in a direction nearly perpendicular to the silicon substrate surface.

According to the fourth means adopted in the present invention, the width of the reflecting mirror is defined relative to a beam spread angle of a semiconductor laser. More particularly, the beam emitted from a semiconductor laser has a spread width approximated by Gaussian distribution. If this spread is intercepted near a light spot of the semiconductor laser, there occurs a Fresnel diffraction phenomenon, which changes into aberration when a spot is formed by an objective lens located just before an optical disc, with consequent decrease in central intensity of the spot. As a result, the power for resolving pits on the optical disc decreases and there occurs an error in a reproduced signal. To avoid this inconvenience, the width of a reflecting mirror is set so as to become wider than the full width at half maximum of the spread of the semiconductor laser beam at the position of the reflecting mirror.

According to the fifth means adopted in the present invention, an amplifier for electrically amplifying light currents generated by photodetectors is formed monolithically on a silicon substrate with the photodetectors formed thereon, and a tilted mirror

alignment index mark is affixed onto the silicon substrate.

According to the six means adopted in the present invention, the above second and fifth means are combined together and a plurality of semiconductor lasers and a monolithically integrated silicon are integrated as hybrid integration with a higher alignment accuracy than that of the index mark.

According to the seventh means adopted in the present invention, an amplifier for electrically amplifying light currents generated by photodetectors is formed monolithically on a silicon substrate with the photodetectors formed thereon, and when semiconductor lasers are soldered onto the silicon substrate with a tilted mirror formed thereon and with an alignment index mark affixed thereto, a material having a high thermal conductivity is interposed between the semiconductor lasers and the silicon substrate for the purpose of widely diffusing the heat generated from the semiconductor lasers.

According to the eighth means adopted in the present invention, an amplifier for electrically amplifying light currents generated by photodetectors is formed monolithically on a silicon substrate with photodetectors formed thereon, and when semiconductor lasers are soldered onto the silicon substrate with a tilted mirror formed thereon and an alignment index mark affixed thereto, a

material having a stress relaxation effect is interposed between the semiconductor lasers and the silicon substrate for the purpose of relaxing a stress induced by a difference in thermal expansion coefficient between the two.

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4. BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram showing an optical head of a single optical path carrying an integrated light source module according to an embodiment of the present invention;

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Fig. 2 is a diagram showing a beam splitting combined element;

Figs. 3A and 3B are structural diagrams of an integrated light source used in the embodiment;

15

Figs. 4A, 4B and 4C are diagrams for explaining the width of a mirror used in the embodiment;

Figs. 5A and 5B are diagrams showing a package form of the integrated light source;

20

Figs. 6A, 6B and 6C are diagrams showing the integrated light source mounted on a horizontal flat package;

Fig. 7 is a diagram showing an integrating substrate for the integrated light source, as well as alignment index, solder and electrode patterns;

25

Fig. 8 is a diagram showing alignment index patterns affixed to semiconductor lasers in the embodiment;

Fig. 9 is a diagram showing a method for alignment between indexed semiconductor laser light sources and an integrating substrate with corresponding index patterns affixed thereto;

5 Fig. 10 is a sectional view taken on line A-A' in Fig. 3A;

Fig. 11 is a sectional view of an integrating substrate having a layer for promoting the radiation of heat from semiconductor laser light sources;

10 Fig. 12 is a diagram showing three types of semiconductor laser light sources mounted on an integrating substrate used in the embodiment; and

Fig. 13 is a diagram showing an OEIC (Optoelectric Integrated Circuit) including an amplifier and
15 photodetectors is integrated monolithically on the integrating substrate.

5. DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 illustrates the configuration of an optical
20 head according to the present invention. An integration module 100 comprises a semiconductor substrate 1, semiconductor laser chips 4a and 4b, a reflecting mirror 5, and photodetectors 7,8 and 9. Laser beams, indicated at 6a and 6b, from the integration module 100 are collimated by a
25 collimator lens 10, then pass through a mirror 11 and a

grating plate 12, and reach an objective lens 13, whereby the beams are formed as spots 15 and 16 on a surface of an optical disc 14. The objective lens 13 comprises plural such lenses according to wavelengths of the semiconductor lasers or a single lens capable of focusing beams of different wavelengths. The objective lens is focused onto a recording surface of the optical disc in accordance with a rotational movement of the same disc by means of an actuator 17 and performs tracking, that is, follows a recording track 18 formed on the disk surface. Thus, in accordance with ON or OFF of the semiconductor lasers, signals are recorded as a train of pits on the optical disc or already recorded pits are read out to reproduce signals. By thus integrating a plurality of semiconductor lasers in the integration module 100, the number of collimator lens 10, that of objective lens 13 and that of mirror 11 each become one and it is possible to singularize the optical path in the optical head. Using this optical head, for example CD, CD-R having a thickness of 1.2 mm can be subjected to recording and reproduction using the semiconductor laser 4a of 780 nm in wavelength, while DVD, DVD-RAM having a thickness of 0.6 mm can be subjected to recording and reproduction using the semiconductor laser 4b of 650 nm in wavelength.

Fig. 2 explains the grating plate 12. This grating

plate is a combined element obtained by integrally laminating a polarizable grating 23 divided into four parts and a quarter wave plate 24 to each other. It is disposed so that the grating 23 faces the semiconductor laser chip side. The polarizable, quartered grating 23 is constituted by a birefringent optical crystal or liquid crystal plate, through which an incident light passes without refraction if it is an ordinary ray or which functions as a diffraction grating if the incident light is an extraordinary ray. When linearly polarized beams 6a and 6b emitted from the semiconductor lasers 4a and 4b are incident on the combined element 12 comprising the polarizable, quartered grating and the quarter wave plate, if they are incident as ordinary rays, pass through the polarizable grating portion and are then made into circularly polarized beams by the quarter wave plate in the combined element 12. The laser beams 6a and 6b after reflected by the optical disc are made into extraordinary rays by the quarter wave plate in the combined element and are then diffracted by the polarizable, quartered grating. The combined element 12 shown in Fig. 2 is divided into four regions by boundary lines 21 and 22. In the same figure, a circle 20 stands for the laser beam 6a or 6b, which is separated into four + 1st order diffracted beams and four -1st order diffracted beams by the quartered

grating. The beams thus separated reach the photodetector 7 or 8 on the semiconductor substrate 1 and are thereby subjected to photoelectric conversion into autofocus signal, tracking signal, and information signal. This point will be described below in detail.

Fig. 3A shows a surface of the semiconductor substrate 1 as seen from the collimator lens 10 side. In the same figure, eight black-painted quarter circles indicated at 32a represent laser beams of wavelength λ_a separated by the grating 23, while eight quarter circles not painted out and indicated at 32b represent laser beams of wavelength λ_b separated by the grating. The photodetector 7, which is for obtaining an out-of-focus detection signal, comprises eight strip-like photodetector elements 7a for receiving the laser beams 32a of wavelength λ_a and eight strip-like photodetector elements 7b for receiving the laser beams 32b of wavelength λ_b . As an out-of-focus detecting method there is adopted a knife edge method (Foucault method), in which wiring is made using an electrically conductive thin film 33 such as aluminum film as shown in Fig. 3A, whereby differential signals are obtained from terminals A and B of wire bonding pads 34. The photodetectors 8 are four photodetectors used for obtaining a tracking error detection signal and an information reproduction signal. Output signals provided

from the four photodetectors 8 pass through an amplifier 35
formed on the semiconductor substrate and are outputted
from terminals D, E, F and G of pads 34. The photodetector
9 is for monitoring the quantities of light beams emitted
5 from the semiconductor laser chips 4a and 4b. An output
signal provided from the photodetector 9 is outputted from
the terminal C of pad 34. Spots 31a and 31b represent
reflected positions on a surface of the reflecting mirror 5
of the laser beams 6a and 6b emitted from the semiconductor
10 chips 4a and 4b, respectively. For example, assuming that
the grating pitches of the four regions shown in Fig. 2
are equal to one another, that grating directions are $+\alpha$,
 $-\alpha$, $+3\alpha$, and -3α degrees with respect to a vertical line
21, and that a focal distance of the collimator lens is f_c ,
15 the laser beams 32a of wavelength λ_a separated by the
grating are focused on a circumference of radius $R_a = f_c \cdot \lambda_a / P$ centered at spot 31a and at positions spaced 2α degree
from the center. Likewise, the laser beams 32b of
wavelength λ_b separated by the grating are focused on a
20 circumference of radius $R_b = f_c \cdot \lambda_b / P$ centered at spot 31b
and at positions spaced 2α degree from the center. If the
spacing D between the light spots of the semiconductor
laser chips 4a and 4b, which is the spacing between the
spots 31a and 31b, is $D \div f_c \cdot (\lambda_b - \lambda_a) / P$, the focused
25 positions of the laser beams of wavelength λ_a and the

focused positions of the laser beams of wavelength λb can be made substantially coincident with each other. Consequently, as in this embodiment, the photodetectors and amplifier can be used in common to beams of different wavelengths, whereby not only the surface of the semiconductor substrate 1 can be saved but also the number of wire bonding pads and output lines can be decreased, with consequent reduction in size of a package which houses the semiconductor substrate therein.

Fig. 3B shows a sectional structure of the semiconductor substrate 1 at the position of dotted line A-A' in Fig. 3A. Preferably, the reflecting mirror 5 is formed at an angle of 45 degrees relative to a laser chip mounting surface 2. For example, the processing for forming a mirror surface on the silicon substrate is based on an anisotropic etching such that if the silicon (100) plane is etched using an aqueous solution of potassium oxide, there is formed a pyramid-shaped concave portion using the flat (111) plane as a slant surface because the etching speed of the (111) plane relative to the (100) plane is lower by approximately two digits. In this case, the angle of the (111) plane relative to the (100) plane is approximately 54.7° , so for forming a reflecting mirror of 45° it is necessary to use a silicon substrate with an off angle of about 9.7° in which a crystallographic axis is

inclined relative to the surface. However, it is necessary that the off angle be determined taking also into account the adaptability of the semiconductor process for the formation of photodetectors and electronic circuits. The reflecting mirror 5 may be displaced from 45° or the direction of emission of the laser beam 6a or 6b may be displaced from the direction perpendicular to the semiconductor substrate 1.

Figs. 4A, 4B and 4C are diagrams explaining at what value the width of the reflecting mirror should be set. Generally, as shown in Fig. 4B, the beam emitted from a semiconductor laser spreads at a certain angle and the intensity distribution relative to the spread angle is approximated by Gaussian distribution. As in the configuration according to the invention shown in Fig. 4A, such a beam is partially reflected by the reflecting mirror 5 in the vicinity of the semiconductor laser 4a or 4b. If a portion of the beam is truncated, there occurs a so-called Fresnel diffraction phenomenon and the phase of wave surface is distorted, as shown in Fig. 4C. If such beams in a distorted state of the wave surface phase reach the objective lens 13, there occurs aberration in the spots 15 and 16 formed on the optical disc. If this point is considered geometrical-opticswise, such a phenomenon does not occur, but this phenomenon can be explained in terms of

a wave-optic model. Since the amount of aberration generated depends on the truncation of beam, it is necessary that the width of the reflecting mirror be taken sufficiently large. In the present invention, the width of the reflecting mirror is set so that the full width at half maximum or more of the semiconductor laser intensity distribution is reflected, as shown in Fig. 4B.

Figs. 5A and 5B show a package for housing the semiconductor substrate 1 therein. The package comprises a package substrate 200 having conductor pins 201, and a silicon substrate 202. Fig. 5B is a sectional view taken on line A-A in Fig. 5A, in which there are used a cap 203 and a package sealing window 204 as components of the package. The window 204 of the package can also serve as the combined element 12 shown in Fig. 1.

Figs. 6A, 6B and 6C show another example of a package with the semiconductor substrate 1 housed therein, of which Fig. 6A shows the structure of the package, Fig. 6B is a sectional view taken on broken line A-A', and Fig. 6C is a sectional view taken on broken line B-B'. Numeral 42 denotes a lead wire, which is connected to the semiconductor substrate 1 through bonding wires of pads 34. A surface of a pedestal 43 for mounting the semiconductor substrate 1 thereon is inclined so that the laser beams 6a and 6b are emitted in a direction perpendicular to the

package. Numeral 44 denotes a glass cover for sealing the semiconductor substrate 1. On an inner side of the glass cover 44 is provided a reflecting surface 45 for reflecting outer peripheral portions of the laser beams 6a and 6b.

5 Beams reflected by the reflecting surface 45 are received by the photodetector 9 on the semiconductor substrate 1, which in turn afford signals for monitoring the quantity of light emitted from each of the semiconductor laser chips 4a and 4b.

10 Now, with reference to Figs. 7, 8, 9, and 10, the following description is provided about a method for mounting a plurality of semiconductor lasers onto a silicon semiconductor substrate. In Fig. 7, index patterns 400 are affixed to the silicon substrate 1 according to the present

15 invention. Numeral 401 denotes a solder pattern, onto which a semiconductor laser is soldered. An electrode pattern 402 is formed and connected to the solder pattern 401. On the other hand, Fig. 8 shows a solder pattern 501 formed on rear sides of the corresponding semiconductor

20 lasers 4a and 4b and index patterns 502 for alignment. Fig. 9 explains a method for alignment between the index patterns 400 formed on the substrate 1 and the index patterns 502 formed on the rear sides of the semiconductor lasers 4a and 4b. In the same figure, the substrate 1 and

25 the semiconductor lasers 4a, 4b are irradiated with an

infrared light 600 from the surface side or the back side, then reflected or transmitted beam is received by a microscope 601, and index patterns are enlarged and projected on a video monitor 602. Further, center positions of the index patterns 400 and 502 are calculated by means of a computer 603 and the substrate 1 or the semiconductor lasers are inched until a positional deviation between two centers becomes zero. Completion of the alignment is followed by tact bonding and subsequent soldering in a solder reflow oven.

Fig. 10 is a sectional view showing a state in which the semiconductor lasers 4a and 4b have been soldered onto the substrate 1 with mirror, which corresponds to a section taken along line A-A' in Fig. 3A. On the rear sides of the semiconductor lasers are formed electrodes 701 and index patterns 502 for alignment, and the semiconductor lasers are soldered onto the substrate 1 with electrode 701 and solder 702 formed thereon. Alignment of the semiconductor lasers and the substrate is performed between index patterns 502 and 703. The beam from the semiconductor laser 4a or 4b forms a light spot 704 and is reflected by the mirror 5, then passes the beam splitter and objective lens and reaches the optical disc. In order that the beam from the light spot 704 should not be truncated by the bottom of the substrate, a pedestal 705 is formed on the

substrate.

Fig. 11 shows an example in which, for improving the radiation of heat, a layer of a material 800 having a high thermal conductivity is disposed just under the semiconductor lasers. The heat generated in an active layer of each semiconductor laser is diffused just thereunder, allowing heat conduction to take place over a wider area to decrease the thermal resistance up to a heat sink. The material layer 800 can be endowed with a function of relaxing a stress induced by a difference in thermal expansion coefficient between the semiconductor lasers and the substrate.

Fig. 13 shows an example in which three semiconductor lasers are arranged in a multi-wavelength module according to the present invention, which lasers are, successively from the right-hand side, a bluish purple color semiconductor laser 810 having a wavelength of approximately 410 nm, a red color laser 306 having a wavelength of approximately 660 nm, and an infrared laser 307 having a wavelength of approximately 780 nm. Three sets of corresponding photodetectors 304, 303 and 811 are formed for tracking, showing an example in which one set of a photodetector serves for both tracking and reproduction signal. These three kinds of wavelengths are associated with recording/reproducing optical discs, including super

DVD, DVD, and CD, which are being standardized.

Fig. 13 illustrates an integration module further embodying the present invention. An amplifier 900 for amplifying light currents provided from photodetectors 303, 304 and 302 is formed monolithically on a silicon or GaN substrate 102, whereby the number of components used is reduced and it is thereby possible to improve the degree of integration.

According to the present invention, as set forth above, it is possible to effect the reduction in size and integration of an optical head which carries a plurality of semiconductor lasers and hence possible to attain the reduction in size and thickness of the whole of an optical disc apparatus for both recording and reproduction such as CD, DVD, and an optical disc capable of carrying bluish purple color lasers.

6. WHAT IS CLAIMED IS:

1. An optical head wherein:

a first laser light source having a first oscillation wavelength for reading or recording data from a recording medium and a second laser light source having a second oscillation wavelength different from or into the first oscillation wavelength are mounted in a recess formed in a substrate a surface of which has been partially removed;

laser beams emitted from said first and second laser light sources are adapted to be reflected by a mirror constituting a part of said recess and to be outputted in a normal direction of the substrate surface or in a direction away from the substrate surface;

a first photodetector means for obtaining out-of-focus detection signals based on the laser beams which have returned after reflected by a surface of said recording medium, a second photodetector means for obtaining a tracking error detection signal and an information

reproduction signal, and a third photodetector means for monitoring the quantity of light emitted from the first or the second laser light source, are provided; and

in said first photodetector means, means for detecting the out-of-focus detection signal based on the

laser beam from the first laser light source and means for

detecting the out-of-focus detection signal based on the laser beam from the second laser light source are spaced away from each other.

2. An optical head according to claim 1, which is disposed within an optical information recording/reproducing apparatus in such a manner that the laser beams which have returned after reflected by the surface of the recording medium are each divided and reach an upper surface of said substrate as a first beam for obtaining the out-of-focus detection signal, a second beam for obtaining the tracking error detection signal and an information reproduction signal, and a third beam for monitoring the quantity of light emitted from the first or the second laser light source.

3. An optical head according to claim 1, wherein said recording medium is any one of an optical information recording and reproducing medium, an optical information reproducing medium, a magneto-optic information recording and reproducing medium, a magneto-optic information reproducing disc, an optical information recording and reproducing disc, a magneto-optic information recording and reproducing disc, and a magneto-optic information reproducing disc.

4. An optical information recording/reproducing

apparatus or an optical information reproducing apparatus,
having the optical head of claim 1, wherein a laser light
source having an oscillation wavelength of 660 nm is used
in the case where the recording medium is a DVD medium,
5 while a laser light source having an oscillation wavelength
of 780 nm is used in the case where the recording medium is
a CD medium.

5. An optical head wherein a first laser light
source having a first oscillation wavelength for reading
10 data from a recording medium and a second laser light
source having a second oscillation wavelength different
from the first oscillation wavelength are mounted in a
recess formed partially in a surface of a substrate;

said first and second oscillation wavelengths being
15 each determined in accordance with the type of said
recording medium, and said laser light sources are used
selectively in accordance with the type of the recording
medium and in conformity with a read wavelength;

laser beams emitted from said first and second laser
20 light sources are adapted to be reflected by a mirror
constituting a part of said recess and to be outputted in a
normal direction of the substrate surface or in a direction
away from the substrate surface;

a first photodetector means for obtaining out-of-
25 focus detection signals, a second photodetector means for

obtaining a tracking error detection signal and an information reproduction signal, and a third photodetector means for monitoring the quantity of light emitted from the first or the second laser light source, are provided; and

5 said first photodetector means having means for detecting the out-of-focus detection signal based on the beam from the first laser light source and means for detecting the out-of-focus detection signal based on the second laser light source.

10 6. An optical head wherein:

20 a first laser light source having a first oscillation wavelength for reading data from a recording medium and a second laser light source having a second oscillation wavelength different from the first oscillation
15 wavelength are mounted in a recess formed partially in a surface of a substrate;

laser beams emitted from said first and second laser light sources are adapted to be reflected by a mirror constituting a part of said recess and to be outputted in a
20 normal direction of the substrate surface or in a direction away from the substrate surface;

25 a first photodetector means for obtaining out-of-focus detection signals, a second photodetector means for obtaining a tracking error detection signal and an information reproduction signal, and a third photodetector

means for monitoring the quantity of light emitted from the first or the second laser light source are formed monolithically on said substrate; and

said first photodetector means has means for
5 detecting the out-of-focus detection signal based on the laser beam from the first laser light source and means for detecting the out-of-focus detection signal based on the laser beam from the second laser light source.

7. An optical head according to claim 6, wherein
10 said first and second laser light sources are disposed adjacent each other so as to permit a single optical path to be used in the optical head.

8. An optical head wherein:

a first laser light source having a first
15 oscillation wavelength for reading data from a recording medium and a second laser light source having a second oscillation wavelength different from the first oscillation wavelength are mounted in a recess formed partially in a surface of a substrate;

20 said substrate and said first laser light source are optically aligned with each other on the basis of alignment marks affixed to the substrate and the first laser light source, respectively, and said substrate and said second laser light source are aligned with each other optically or
25 by image processing on the basis of alignment marks affixed

to the substrate and the second laser light source,
respectively;

laser beams emitted from said first and second laser
light sources are adapted to be reflected by a mirror
5 constituting a part of said recess and to be outputted in a
normal direction of the substrate surface or in a direction
away from the substrate surface;

a first photodetector means for obtaining out-of-
focus detection signals, a second photodetector means for
10 obtaining a tracking error detection signal and an
information reproduction signal, and a third photodetector
means for monitoring the quantity of light emitted from the
first or the second laser light source are formed
monolithically on the substrate; and

15 said first photodetector means having means for
detecting the out-of-focus detection signal based on the
laser beam from the first laser light source and means for
detecting the out-of-focus detection signal based on the
laser beam from the second laser light source.

20 9. An optical head according to claim 8, wherein
said second and third photodetector means have
photodetection sensitivity for the laser beams of the first
and second oscillation wavelengths.

10. An optical head wherein:

25 a first laser light source having a first

oscillation wavelength for reading data from a recording medium and a second laser light source having a second oscillation wavelength different from the first oscillation wavelength are mounted in a recess formed partially in a surface of a substrate;

said first and second oscillation wavelengths being determined in accordance with the type of said recording medium, and said first and second laser light sources being used selectively in accordance with the type of the recording medium and in conformity with a read wavelength;

laser beams emitted from said first and second laser light sources are adapted to be reflected by a mirror constituting a part of said recess and to be outputted in a normal direction of the substrate surface or in a direction away from the substrate surface;

said first or second laser light source and said mirror which extend from a bottom of said recess to the outside of the recess are in a spatial arrangement relation such that a laser beam portion wider than a full width at half maximum in an intensity distribution of the laser beam emitted from the first or the second laser light source is reflected by the mirror.

11. An optical head wherein:

a first laser light source having a first oscillation wavelength and a second laser light source

having a second oscillation wavelength different from the first oscillation wavelength are mounted in a recess formed partially in a surface of a substrate;

laser beams emitted from said first and second laser
5 light sources are adapted to be reflected by a mirror constituting a part of said recess and to be outputted in a normal direction of the substrate surface or in a direction away from the substrate surface; and

said first or the second laser light source and said
10 mirror which extends from a bottom of said recess to the outside of the recess are in a spatial arrangement relation such that most of the laser beam emitted from the first or the second laser beam source is reflected by the mirror.

12. An optical head wherein:

15 a first laser light source having a first oscillation wavelength and a second laser light source having a second oscillation wavelength different from the first oscillation wavelength are mounted in a recess formed partially in a surface of a substrate;

20 laser beams emitted said first and second laser light sources are adapted to be reflected by a mirror constituting a part of said recess and to be outputted in a normal direction of the substrate surface or in a direction away from the substrate surface; and

25 said first or second laser light source and said

mirror which extends from a bottom of said recess to the outside of the recess each have a predetermined width so that a beam portion wider than a full width at half maximum in an intensity distribution of the laser beam emitted from the first or the second laser light source is reflected by the mirror.

13. A method for fabricating an optical head, comprising the steps of:

forming monolithically on a substrate a first photodetector means for obtaining out-of-focus detection signals, a second photodetector means for obtaining a tracking error detection signal and an information reproduction signal, and a third photodetector means for monitoring the quantity of light emitted from a first or a second laser light source;

forming a recess partially in a surface of said substrate, said recess having a slant face which functions as a mirror for reflecting laser beams, and mounting in said recess the first laser light source which has a first oscillation wavelength and the second laser light source which has a second oscillation wavelength different from the first oscillation wavelength; and

forming, as said first photodetector means, means for detecting the out-of-focus detection signal based on the laser beam from said first laser light source and means

for detecting the out-of-focus detection signal based on the laser beam from said second laser light source in such a manner that both said means are spaced away from each other.

- 5 14. A method for fabricating an optical head, comprising the steps of:

forming monolithically on a substrate a first photodetector means for obtaining out-of-focus detection signals, a second photodetector means for obtaining a tracking error signal and an information reproduction signal, and a third photodetector means for monitoring the quantity of light emitted from a first or a second laser light source;

- 15 forming a recess partially in a surface of said substrate, said recess having a slant face which functions as a mirror for reflecting laser beams, fixing into said recess the first laser light source which has a first oscillation wavelength and the second laser light source which has a second oscillation wavelength different from the first oscillation wavelength in such a manner that laser beams are emitted from the first and second laser light sources at positions different from the fixed side of both said laser light sources to the recess and are reflected by said mirror; and

- 25 forming, as said first photodetector means, means

for detecting the out-of-focus detection signal based on the laser beam from the first laser light source and means for detecting the out-of-focus detection signal based on the laser beam from the second laser light source in such a manner that both said means are spaced away from each other.

15. A method for fabricating an optical head, comprising the steps of:

forming monolithically on a substrate a first photodetector means for obtaining out-of-focus detection signals, a second photodetector means for obtaining a tracking error detection signal and an information reproduction signal, and a third photodetector means for monitoring the quantity of light emitted from a first or a second laser light source; and

forming a recess partially in a surface of said substrate, said recess having a slant face which functions as a mirror for reflecting laser beams, and fixing into said recess the first laser light source which has a first oscillation wavelength and the second laser light source which has a second oscillation wavelength different from the first oscillation wavelength in such a manner that laser beams are emitted from the first and second laser light sources at positions different from the fixed side of both said laser light sources to the recess and are reflected by said mirror.

16. A method for fabricating an optical head,
comprising the steps of:

mounting a first laser light source having a first
oscillation wavelength and a second laser light source
5 having a second oscillation wavelength different from the
first oscillation wavelength into a recess formed partially
in a surface of a substrate in such a manner that laser
beams emitted from the first and second laser light sources
are reflected by a mirror constituting a part of said
10 recess and to be outputted in a normal direction of the
substrate surface or in a direction away from the substrate
surface;

forming monolithically a first photodetector means
for obtaining out-of-focus detection signals, a second
15 photodetector means for obtaining a tracking error
detection signal and an information reproduction signal,
and a third photodetector means for monitoring the quantity
of light emitted from the first and second laser light
sources; and

20 forming, as said first photodetector means, means
for obtaining the out-of-focus detection signal based on
the laser beam from the first laser light source and means
for obtaining the out-of-focus detection signal based on
the laser beam from the second laser light source in such a
25 manner that both said means are spaced away from each other.

17. A method for fabricating an optical head,
comprising the steps of:

mounting a first laser light source having a first
oscillation wavelength and a second laser light source
5 having a second oscillation wavelength different from the
first oscillation wavelength into a recess formed partially
in a surface of a substrate in such a manner that laser
beams emitted from said first and second laser light
sources are reflected by a mirror constituting a part of
10 said recess and to be outputted in a normal direction of
the substrate surface or in a direction away from the
substrate surface; and

adjusting a spatial arrangement relation between
said first or said second laser light source and said
15 mirror which extends from a bottom of said recess to the
outside of the recess in such a manner that a laser beam
portion wider than a full width at half maximum in an
intensity distribution of the laser beam emitted from the
first or the second laser light source is reflected by the
20 mirror.

18. A method for fabricating an optical head,
comprising the steps of:

mounting a first laser light source having a first
oscillation wavelength and a second laser light source
25 having a second oscillation wavelength different from the

first oscillation wavelength into a recess formed partially in a surface of a substrate in such a manner that laser beams emitted from the first and second laser light sources are reflected by a mirror constituting a part of said
5 recess and to be outputted in a normal direction of the substrate surface or in a direction away from the substrate surface; and

adjusting a spatial arrangement relation between said first or said second laser light source and said
10 mirror which extends from a bottom of said recess to the outside of the recess in such a manner that most of the laser beam emitted from the first or the second laser light source is reflected by the mirror.

19. A method for fabricating an optical head,
15 comprising the steps of:

mounting a first laser light source having a first oscillation wavelength and a second laser light source having a second oscillation wavelength different from the first oscillation wavelength into a recess formed partially
20 in a surface of a substrate in such a manner that laser beams emitted from said first and second laser light sources are reflected by a mirror constituting a part of said recess and to be outputted in a normal direction of the substrate surface or in a direction away from the
25 substrate surface;

forming said first or second laser and said mirror, which extends from a bottom of said recess to the outside of the recess, each at a predetermined width so that a laser beam portion wider than a full width at half maximum in an intensity distribution is reflected by the mirror.

20. An optical head for recording and reproducing information to and from an optical disc corresponding to an oscillation wavelength of a semiconductor laser, comprising a light source module, a beam splitter, and an objective lens, along a single optical path, said light source module comprising a plurality of semiconductor lasers and mounted on a semiconductor substrate with photodetectors for automatic focus detection and tracking detection formed thereon monolithically, said semiconductor lasers being different in wavelength in association with the optical disc.

21. An optical head for recording and reproducing information to and from an optical disc, said optical disc carrying an integration module, said integration module comprising a plurality of semiconductor lasers of different wavelengths and a semiconductor substrate with photodetectors for automatic focus detection and tracking detection formed thereon monolithically, said photodetectors having sensitivity at the corresponding wavelengths, wherein an alignment mark is affixed to one or

both of said semiconductor lasers and said semiconductor substrate.

22. An optical head for recording and reproducing information to and from an optical disc, said optical head carrying an integration module, said integration module comprising a plurality of semiconductor lasers of different wavelengths and a semiconductor substrate with photodetectors for automatic focus detection and tracking detection formed thereon monolithically, said photodetectors having sensitivity at the corresponding wavelengths, wherein a tilted mirror is formed in said semiconductor substrate, and an alignment mark is affixed to one or both of said semiconductor lasers and said semiconductor substrate.

23. An optical head for recording and reproducing information to and from an optical disc, said optical head carrying an integration module, said integration module comprising a plurality of semiconductor lasers of different wavelengths and a semiconductor substrate with photodetectors for automatic focus detection and tracking detection formed thereon monolithically, said photodetectors having sensitivity at the corresponding wavelengths, wherein a tilted mirror is formed in said semiconductor substrate so as to have a width which reflects a laser beam portion wider than a full width at

half maximum in an intensity distribution of the laser beam emitted from any of the semiconductor lasers, and an alignment mark is affixed to one or both said semiconductor lasers and said semiconductor substrate.

5 24. An optical head for recording and reproducing information to and from an optical disc, said optical head carrying an integration module, said integration module comprising a plurality of semiconductor lasers of different wavelengths and a semiconductor substrate with
10 photodetectors for automatic focus detection and tracking detection formed thereon monolithically, said photodetectors having sensitivity at the corresponding wavelengths, wherein an amplifier for amplifying light currents from said photosensors is formed monolithically on
15 said semiconductor substrate, a tilted mirror is formed in the semiconductor substrate, and an alignment mark is affixed to one or both of said semiconductor substrate or said semiconductor lasers.

20 25. An optical head for recording and reproducing information to and from an optical disc, said optical head carrying an integration module, said integration module comprising a plurality of semiconductor lasers of different wavelengths, photodetectors for automatic focus detection and tracking detection, and a semiconductor substrate,
25 wherein the photodetectors and a light current amplifier

are formed monolithically on said semiconductor substrate, a tilted mirror is formed in the semiconductor substrate, alignment marks are affixed to said semiconductor lasers and said semiconductor substrate at respective contacting
5 surfaces, and alignment is made by image processing with use of a transmitted or reflected light of infrared light.

26. An optical head for recording and reproducing information to and from an optical disc, said optical head carrying an integration module, said integration module
10 comprising a plurality of semiconductor lasers of different wavelengths, photodetectors for automatic focus detection and tracking detection, and a semiconductor substrate, wherein the photodetectors are formed monolithically on said semiconductor substrate and a tilted mirror is formed
15 in the substrate, alignment marks are affixed to both said semiconductor lasers and said semiconductor substrate, and a material superior in thermal conductivity is disposed in a contact portion between the semiconductor lasers and the semiconductor substrate.

27. An optical head for recording and reproducing information to and from an optical disc, said optical head carrying an integration module, said integration module
20 comprising a plurality of semiconductor lasers of different wavelengths, photodetectors for automatic focus detection and tracking detection, and a semiconductor substrate,
25

wherein the photodetectors are formed monolithically on said semiconductor substrate and a tilted mirror is formed in the substrate, alignment marks are affixed to both said semiconductor lasers and said semiconductor substrate, and a material having a stress relaxing effect is disposed in a contact portion between the semiconductor lasers and the semiconductor substrate.

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7. ABSTRACT

It is a subject of the disclosed invention to attain the integration of an optical head for recording and reproducing information to and from optical discs of different types, including CD and DVD, with use of a single information recording/reproducing apparatus.

A solution is to integrate a plurality of semiconductor lasers of different wavelengths by index alignment onto a substrate formed with OEIC, PD patterns and a reflecting mirror.

FIG. 1

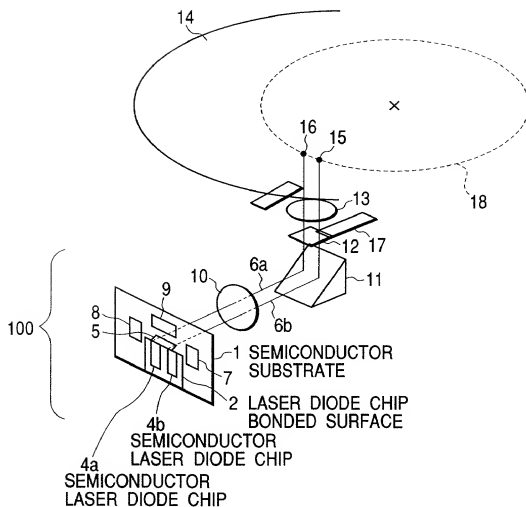


FIG. 2

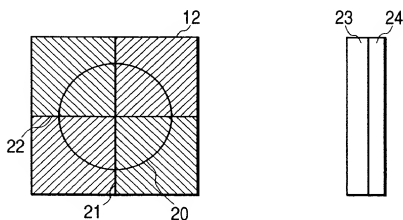


FIG. 3A

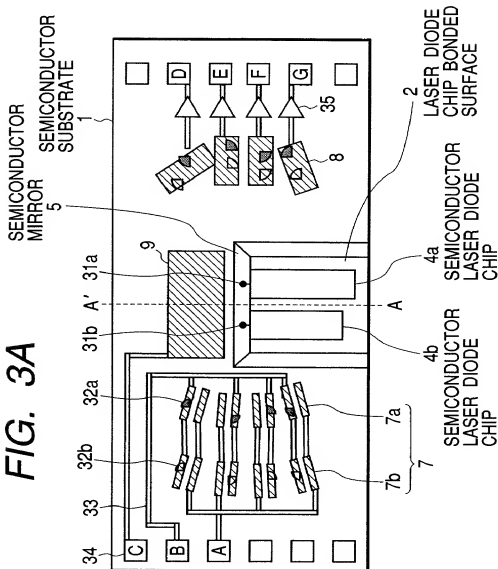


FIG. 3B

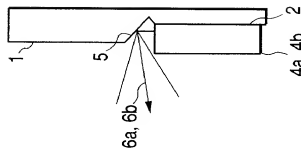
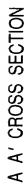


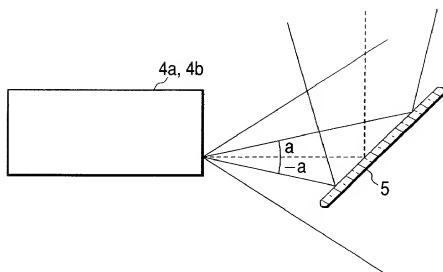
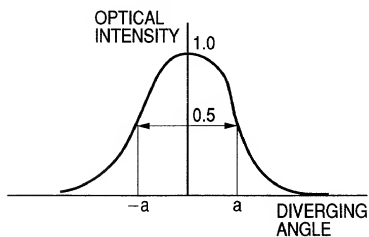
FIG. 4A**FIG. 4B****FIG. 4C**

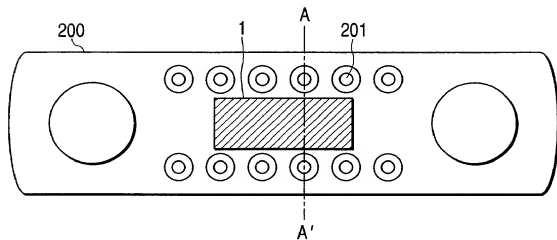
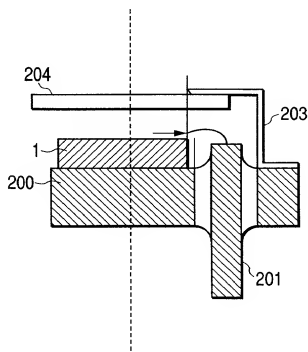
FIG. 5A**FIG. 5B**

FIG. 6A

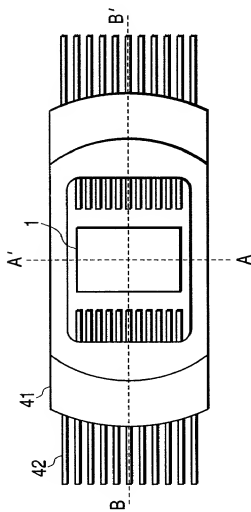


FIG. 6B

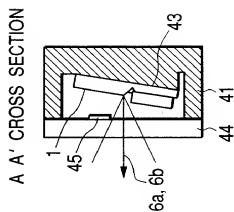


FIG. 6C

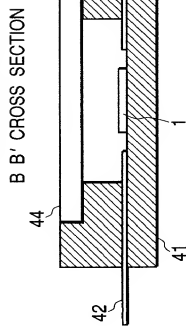


FIG. 7

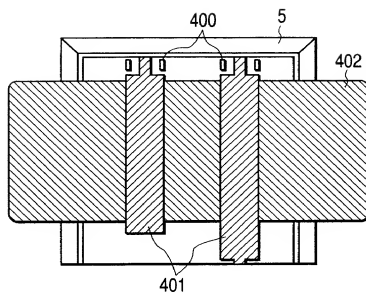


FIG. 8

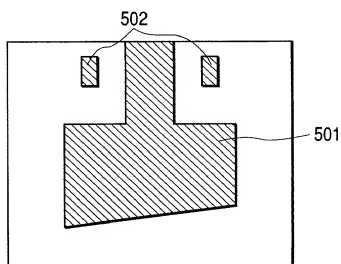


FIG. 9

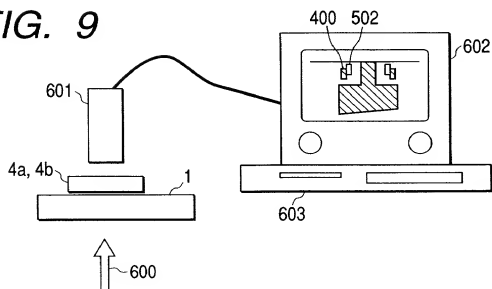


FIG. 10

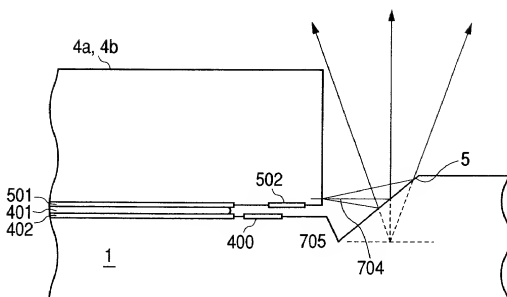


FIG. 11

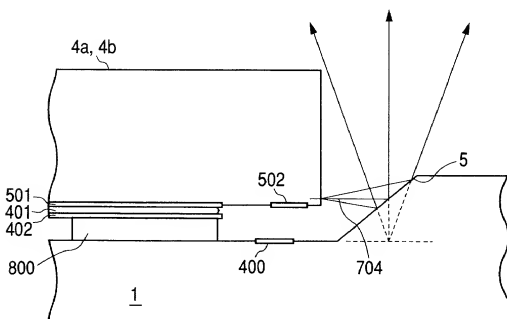


FIG. 12

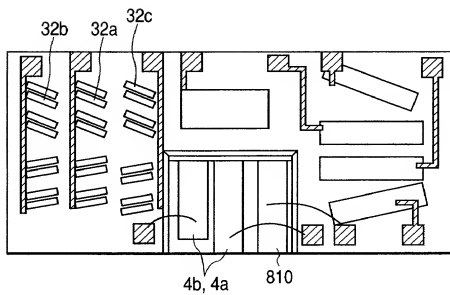
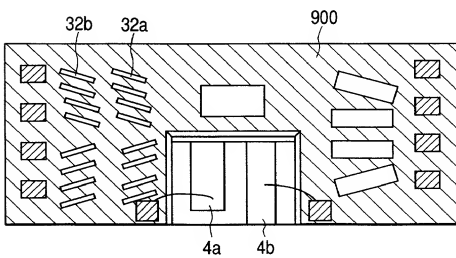


FIG. 13



Declaration and Power of Attorney For Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

OPTICAL HEAD AND FABRICATION METHOD

上記発明の明細書（下記の欄で×印がついていない場合は、本書に添付）は、

The specification of which is attached hereto unless the following box is checked:

☐ 月 日に提出され、米国出願番号または特許協定条約国際出願番号を _____ とし、
(該当する場合) _____ に訂正されました。

☐ was filed on _____
as United States Application Number or
PCT International Application Number
_____ and was amended on _____
(if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編第1条56項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

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私は、米国法典第35編119条 (a)-(d) 項又は365条(b) 項に基づき下記の、米国外の国の少なくとも一カ国を指定している特許協力条約365 (a) 項に基づく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示している。

Prior Foreign Application(s)

外国での先行出願

11-232136 (Number) (番号)	Japan (Country) (国名)
(Number) (番号)	(Country) (国名)

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Priority Not Claimed
優先権主張なし

19/August/1999 (Day/Month/Year Filled) (出願年月日)	<input type="checkbox"/>
(Day/Month/Year Filled) (出願年月日)	<input type="checkbox"/>

私は、第35編米国法典119条 (e) 項に基づいて下記の米国特許出願規定に記載された権利をここに主張いたします。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below

(Application No.) (出願番号)	(Filing Date) (出願日)
-----------------------------	------------------------

(Application No.) (出願番号)	(Filing Date) (出願日)
-----------------------------	------------------------

私は、下記の米国法典第35編120条に基づいて下記の特許出願に記載された権利、又は米国外の指定している特許協力条約365条 (c) 項に基づく権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第35編112条第1項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日より本出願書の日本国内または特許協力条約国際提出日よりの期間中に入手された、連邦規則法典第37編1.56条で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

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(Application No.) (出願番号)	(Filing Date) (出願日)
(Application No.) (出願番号)	(Filing Date) (出願日)

(Status: Patented, Pending, Abandoned) (現況: 特許許可済、係属中、放棄済)
(Status: Patented, Pending, Abandoned) (現況: 特許許可済、係属中、放棄済)

私は、私自身の知識に基づいて本宣言書中で私が行なう表明が真実であり、かつ私の入手した情報と私の信じているところに基づき表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第18編第1001条に基づき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行なえば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣言を致します。
I hereby declare that all statements made herein of my own

knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Japanese Language Declaration

(日本語宣言書)

委任状： 私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。(弁理士、または代理人の氏名及び登録番号を明記のこと)

POWER OF ATTORNEY. As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number)

Thomas E. Beall, Jr., Reg. No.22,410; John R. Mattingly, Reg. No.30,293; Daniel J. Stanger, Reg. No.32,846; Shrinath Malur, Reg. No.34,663; Gene W. Stockman, Reg. No.21,021; Jeffrey M. Ketchum, Reg. No.31,174; and Scott W. Brickner, Reg. No.34,553

書類送付先

Send Correspondence to:

BEALL LAW OFFICES

104 East Hume Avenue

Alexandria, Virginia 22301

直接電話連絡先：(氏名及び電話番号)

Direct Telephone Calls to: (name and telephone number)

Telephone: (703) 684-1120

Fax: (703) 684-1157

唯一または第一発明者

Full name of sole or first inventor

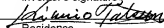
Kimio TATSUNO

発明者の署名

日付

Inventor's signature

Date

 Feb 8th 2000

住所

Residence

Tokyo, Japan

国籍

Citizenship

Japan

私書箱

Post Office Address

c/o Hitachi, Ltd., Intellectual Property Group
New Marunouchi Bldg. 5-1, Marunouchi 1-chome,
Chiyoda-ku, Tokyo 100-8220, Japan

(第二以降の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for second and subsequent joint inventors.)

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number

第二共同発明者		Full name of second joint inventor, if any Masahide TOKUDA	
第二共同発明者の署名	日付	Second inventor's signature <i>Masahide Tokuda</i>	Date 2/15/2000
住所	Residence Ome, Japan		
国籍	Citizenship Japan		
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan		
第三共同発明者		Full name of third joint inventor, if any Hirohisa SANO	
第三共同発明者の署名	日付	Third inventor's signature <i>Hirohisa Sano</i>	Date 2/8/2000
住所	Residence Niiza, Japan		
国籍	Citizenship Japan		
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan		
第四共同発明者		Full name of fourth joint inventor, if any Toshiaki TANAKA	
第四共同発明者の署名	日付	Fourth inventor's signature <i>Toshiaki Tanaka</i>	Date 2/8/2000
住所	Residence Kodaira, Japan		
国籍	Citizenship Japan		
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan		
第五共同発明者		Full name of fifth joint inventor, if any Takeshi SHIMANO	
第五共同発明者の署名	日付	Fifth inventor's signature <i>Takeshi Shimano</i>	Date 2/10/2000
住所	Residence Tokorozawa, Japan		
国籍	Citizenship Japan		
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan		

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第六共同発明者	Full name of sixth joint inventor, if any
Shigeru NAKAMURA	
第六共同発明者の署名 日付	Sixth inventor's signature Date
<i>Shigeru Nakamura</i> 2/9/2000	
住所	Residence
Tachikawa, Japan	
国籍	Citizenship
Japan	
私書箱	Post Office Address
c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan	
第七共同発明者	Full name of seventh joint inventor, if any
Takeshi MAEDA	
第七共同発明者の署名 日付	Seventh inventor's signature Date
<i>Takeshi Maeda</i> 2/16/2000	
住所	Residence
Kokubunji, Japan	
国籍	Citizenship
Japan	
私書箱	Post Office Address
c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan	
第八共同発明者	Full name of eighth joint inventor, if any
Akira ARIMOTO	
第八共同発明者の署名 日付	Eighth inventor's signature Date
<i>Akira Arimoto</i> 2/14/2000	
住所	Residence
Huchu, Japan	
国籍	Citizenship
Japan	
私書箱	Post Office Address
c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan	
第九共同発明者	Full name of ninth joint inventor, if any
第九共同発明者の署名 日付	Ninth inventor's signature Date
住所	Residence
国籍	Citizenship
私書箱	Post Office Address

LIST OF INVENTORS' NAMES AND ADDRESSES

Kimio TATSUNO, Tokyo, JAPAN;

Masahide TOKUDA, Ome, JAPAN;

Hirohisa SANO, Niiza, JAPAN;

Toshiaki TANAKA, Kodaira, JAPAN;

Takeshi SHIMANO, Tokorozawa, JAPAN;

Shigeru NAKAMURA, Tachikawa, JAPAN;

Takeshi MAEDA, Kokubunji, JAPAN;

Akira ARIMOTO, Huchu, JAPAN.